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Gun and Non-Gun Related Violence Exposure and Risk for Subsequent Gun Carrying Among Male Juvenile Offenders

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Abstract

Objective—Although studies have found that youth exposed to violence are more likely to carry guns than non-exposed youth, this association could be due to common causal factors or other pre-existing differences between individuals. In this study, within-individual change models were used to determine whether juvenile offenders exhibit an increased propensity to carry a firearm after being exposed to gun violence and/or non-gun violence. The advantage of this approach is all time-invariant factors are eliminated as potential confounders.

Method—1170 racially/ethnically diverse male juvenile offenders were recruited in Arizona and Pennsylvania (ages 14–19 at recruitment). Participants were interviewed every six months for three years followed by four annual assessments. The outcome was gun carrying and the primary predictors were exposure to gun violence and non-gun violence. Time-varying covariates included exposure to peers who carried guns, exposure to peers who engaged in other (non-gun) criminal acts, developmental changes in gun carrying, and changes in gun carrying due to incarceration/institutionalization.

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Results—Adolescent offenders were significantly more likely to carry a gun in recall periods following exposure to gun violence, but not after exposure to non-gun violence. Effect of gun violence on carrying was significant throughout adolescence and young adulthood, and could not be accounted for by time-varying and time-invariant confounders.

Conclusions—Interventions to reduce illegal gun carrying should target young men in medical and mental health settings who experience or witness gun violence, as well as those living in communities with high rates of gun violence.

Keywords

gun violence; victimization; gun/firearm use

Firearm violence is a problem that disproportionately affects young men and is associated with high injury and financial costs for victims, as well as broader costs to society (1, 2). Given the serious costs associated with firearm violence, former President Obama, congressional leaders, and international health agencies have called for increased efforts to understand the mechanisms that lead young men to illegally carry guns (3, 4). One compelling and intuitively appealing hypothesis is that adolescents and young adults carry guns for self-protection and/or retaliation after being victimized or witnessing violence (5–9). Evidence of this association has been found in cross-sectional and short-term longitudinal observational studies (10–18) and in retrospective reports of juvenile offenders assessing reasons for gun carrying (19). However, this body of work suffers from several limitations.

The most significant limitation of prior studies is a failure to rule-out between-individual differences (i.e., confounders) that might account for the observed associations between violence exposure and gun carrying. Previously reported associations could be due to common causal factors in childhood that influence subsequent violence exposure and gun carrying (e.g., low family SES, disinhibited temperament), as well as increased affiliation with delinquent peers during adolescence. The present study was designed to overcome these limitations by using within-individual change models to test the fundamental assumption that when an adolescent is exposed to violence, he is more likely to subsequently carry a gun. Importantly, these analyses also controlled for time-invariant effects of all pre-existing and time-invariant factors and changes in exposure to delinquent peers as potential confounders.

Background Research

Violent victimization and/or witnessing violence (collectively referred to as exposure to violence) are strong predictors of gun carrying and firearm violence among male adolescents and young adults (7). Specifically, numerous cross-sectional studies (10, 12, 16, 18), and a limited number of longitudinal studies (11, 13–15, 17), have found that adolescents who are directly or indirectly exposed to violence are more likely to carry a firearm than adolescents who are not exposed to violence. However, these studies suffer from several key limitations that significantly weaken their ability to infer a causal link between exposure to violence and gun carrying.

For instance, almost all existing studies have examined concurrent associations between violence exposure and gun carrying, making it impossible to establish a time-ordered cause-effect relationship. Indeed existing longitudinal studies have not examined the basic premise that an adolescent's propensity to carry a gun increases *after* he experiences an increased exposure to violence. In order to directly test this assumption, longitudinal analyses must isolate within-individual changes in both exposure to violence and gun carrying across multiple assessments. Additionally, the few longitudinal studies that have been able to establish some degree of temporal ordering have focused primarily on mixed sex community samples (13–15, 17). Therefore, the findings are not generalizable to male adolescents with a history of serious criminal offending, a population at particularly high risk for being violently victimized and engaging in illegal gun carrying. Finally, prior investigations have not controlled for the myriad pre-existing and time-stable factors that may account for the observed links between exposure to violence and gun carrying.

The Present Study

This study was designed to examine the potential causal linkage between adolescent exposure to both gun- and non-gun-related violence and subsequent gun carrying among a large racially/ethnically diverse sample of male juvenile offenders. Participants were assessed every six months for three years and then annually for four years. A significant strength of this study is the focus on a sample of male serious juvenile offenders, a group that is disproportionately exposed to gun- and non-gun violence and also at high risk for carrying guns and shooting others (20–22). The availability of repeated assessments provided the unique opportunity to use within-individual change analyses to examine whether an individual's own propensity to engage in gun carrying increased after being exposed to gun-related and/or non-gun-related violence. By focusing on within-individual change, all pre-existing and time-invariant effects that varied between individuals were ruled out as potential confounders, thereby strengthening causal inferences. Further, the present study specifically examined whether exposure to both gun- and non-gun-related violence were associated with an increased risk for future gun carrying, which is a distinction that no prior study has examined. Isolating the specific mechanisms that raise the risk of future gun carrying is the first step in building the foundation for effective interventions. In addition, the present study controlled for several potential time-varying confounders. In particular, we controlled for two measures of peer delinquency (peer gun use and peer general delinquency), given that several studies have found that peer delinquency is one of the strongest and most consistent predictors of gun use in adolescence and young adulthood (23, 24). We also controlled for offenders' opportunity to carry a gun by including one variable that indicated whether participants were incarcerated and another variable that represented the amount time participants spent "on the streets" during each recall period.

Finally, we tested whether the linkage between exposure to violence and gun carrying changed as juvenile offenders transitioned from adolescence to the mid-20s. Given that adolescents might be more vulnerable to, and have less control over, the social environments to which they are exposed (25, 26), exposure to violence might have a stronger influence on subsequent carrying for adolescents than young adults.

Method

The sample consisted of 1,170 racially/ethnically diverse (42.1% Black; 34.0% Latino; 19.2% White; 4.6% other) male juvenile offenders enrolled in the Pathways to Desistance Study (2000–2010)(27). All study participants were recently adjudicated for a serious offense (94% felonies) in either Maricopa County, Arizona or Philadelphia County, Pennsylvania. Participants were between the ages of 14 and 19 at the baseline interview (*mean age* = 16.6, *SD* = 1.12). At any given time-point, the percent of youth on active probation ranged from about 23% to 70% (with the percent highest at Time 1 and decreasing across time), and of those on probation, probation officers contacted youth an average of 1.80 times per month (*SD* = 3.54; range 0 to 58). More extensive details on the sample and study methodology have been published elsewhere (27).

All youth completed a baseline interview following their adjudication hearing. Study participants were then interviewed every six months for three years, followed by four annual interviews. This study focused on the six bi-annual and four annual follow up interviews. Informed parental consent and youth assent were attained prior to study initiation. Trained interviewers administered all questionnaires to youth in a private setting, with most interviews taking place in participants' homes. Interviews were also conducted in secure detention or other residential facilities when necessary. Youth were financially compensated for their time. All procedures were approved by the Universities' Institutional Review Boards.

Measures

Exposure to Gun and Non-Gun Violence—The Exposure to Violence inventory (ETV) (28) was used to assess time-varying measures of direct and vicarious exposure to gun- and non-gun related violence. The four items assessing exposure to gun violence asked participants whether they had been shot/shot at since the previous interview and whether they had seen others victimized in the same manner. The six items assessing exposure to non-gun violence asked participants whether they had been beaten up, raped, or chased by someone who wanted to seriously hurt them during the recall period and whether they had seen others victimized in the same manner. Two binary constructs were created to indicate whether the youth was exposed to any gun- or non-gun violence during each recall period (1=Yes; 0=No).

Gun Carrying—Gun carrying was assessed with a single item from the Self-Report of Offending scale (SRO) (29). At each interview, youth reported whether they carried a gun since the previous interview (1=Yes; 0=No).

Time-Varying Confounding Variables—The time participants spent in the community where they could access firearms during each recall window varied across the 10 assessments due to periods of institutional placement and differences in lengths of time between interviews (i.e., 6 month versus 12 month gaps). To control for this difference in exposure time, a variable indexing the number of months that participants spent in the community was included as a covariate (called *street months*). This was calculated by subtracting the number of self-reported days spent in secure confinement during the recall

period from the total number of days between interviews and dividing the result by 30. A variable indexing whether the participant was incarcerated for any duration during the recall period was also included as a covariate (1=Yes; 0=No).

We also controlled for two measures of peer delinquency using the self-reported Peer Delinquency Scale (PDS) (30), given that affiliation with delinquent peers is one of the most robust predictors of adolescent criminal behavior, including gun carrying (23, 24, 31, 32).

Each item on the Peer Delinquency scale asked participants to rate how many of their friends engaged in various antisocial acts using a five-point rating scale ("None of them" to "All of them"). First, a *gun-related peer delinquency* scale was created using a single item asking participants how many of their friends carried a gun. The two higher categories on this item ("Most of them" and "All of them") were combined because they were endorsed by a small number of participants. Controlling for peer gun use is important, given that prior studies have found that peer gun carrying is significantly associated with adolescents' and young adults' own gun carrying (23, 24, 33). Second, a general (*non-gun-related)* peer delinquency scale was created by averaging the remaining 17 items on the Peer Delinquency scale, given that general measures of peer delinquency have also been associated with weapon carrying in adolescence and young adulthood (18, 34, 35). Items on the non-gun related peer delinquency scale assessed the extent to which youths' peers engaged in behaviors such as violence, theft, vandalism, and drug dealing/use. One item, number of friends who had gotten high on drugs, was added late in the study, which resulted in a mean of 18-items for peer non-gun delinquency for Time 4-Time 10 (and a mean of 17 items for Time 1–3). We re-ran our primary model while controlling for probation status (on probation or not), average number of probation officer contacts per month, gainful activity (enrolled in school or legally employed), drug dealing (any drug dealing, marijuana only drug dealing, other/non- marijuana drug dealing only), gang membership, neighborhood disadvantage, and alcohol use (frequency of use, binge drinking, number of times drunk) in separate and combined models. Because none of these variables were significantly associated with gun carrying, we retained the primary model, which controlled for institutional placement, street time, peer gun use, and peer non-gun delinquency.

Plan of analysis

Missing data—Sample retention for the 10 assessments was high, averaging 89% and never falling below 82%. Of the 1,170 participants, 730 completed all 10 assessments (62.39%). Approximately 16% missed one interview, 7% missed two interviews, 4% missed three interviews, and 10% missed four or more interviews. Forty young men died before the end of the study period (3.42%). Black youth were more likely to have any missing data than White ($z = 4.38$, $p<.001$) and Hispanic ($z = 3.94$, $p<.001$) youth. Additionally, youth who were older at baseline were more likely to have missing data ($z = 2.41$, $p = .016$). Importantly, gun carrying prior to baseline (carried in past 6 months, carried but not in past 6 months) was not associated with having missing data.

To avoid discarding cases with incomplete data, multiple imputation was implemented using the MICE procedure (multiple imputation by chained equations) with Stata 14.2. MICE fills in incomplete cases using multiple values drawn from varying distributions based on the

nature of the individual variable (e.g., logit for binary variables; ordered logit for ordinal variables) to create *M* complete datasets. MI provides approximately unbiased and efficient estimates under the assumption that the missing data mechanism is “ignorable”, i.e., unrelated to any of the missing values after adjusting for the observed values. A total of 20 imputed datasets were created, with all study variables being included in the imputation models. Analyses were conducted on each dataset and the results were combined using Rubin’s rules (36, 37).

Prior to conducting MI, values on the dependent variable of gun carrying were coded as missing for assessments when participants reported spending the entire recall period in secure confinement. This was done because participants had no opportunity to carry a firearm during these periods, resulting in what is referred to as ‘structural zeroes’ on the dependent variable. Failing to differentiate these periods of non-gun carrying from those due to sampling variability can distort study findings.

Analytic models—The present study examined whether young men’s odds of carrying a gun increased during recall periods *after* they were exposed to gun or non-gun violence. To address this issue, fixed effects binary logistic regressions (within-individual change models) were run within a structural equation framework (38, 39). These models can be defined using the following equation:

$$\text{logit}(P_{it}) = \beta_1 \text{ExGunVio}_{it-1} + \beta_2 \text{ExNonGunVio}_{it-1} + \sum \beta z \text{Covariates}_{it} + \alpha_i + \mu_t + \varepsilon_{it}$$

where…

- P_{it} represents the probability that person i reports carrying a gun at time t.
- Effects of gun violence (β_1) and non-gun violence (β_2) were constrained to be equal across time.
- $\Sigma\beta z$ Covariates_{it} = Sum of the effects of all time-varying covariates for individual i at time t.
- α_i =fixed constant indexing the probability of gun carrying for each individual i.
- μ_t = fixed constant for each time point, allowing unrestricted changes in the probability of carrying over time (effectively controlling for time-varying age effects).
- ε_{it}=random error for individual i at time t

This modeling strategy focuses on change at the level of the individual, leaving all constant and pre-existing factors that vary between individuals (e.g., race, early rearing environment) —whether measured or not—automatically controlled (38). Although time invariant factors, such as race or disinhibited temperament, might explain why one individual has a higher likelihood of carrying a gun at any given time than another individual, time-invariant factors cannot explain why an individual’s likelihood of carrying a gun changes from time-point to time-point. Only time-varying factors (e.g., whether he was exposed to violence during the

recall period) can explain changes in one's own gun carrying behavior (i.e., why an individual might carry a gun in some recall periods, but not others).

All fixed effects models were estimated using Mplus version 7 (40). The final model predicting gun carrying at Time T included the effects of exposure to gun violence (lagged 1 time-point; "T-1"), exposure to non-gun violence (T-1), institutional placement (T), street months (T), peer gun carrying (T-1), and peer non-gun related delinquency (T-1).

The final model was then modified to test whether the magnitude of the associations between exposure to violence and gun carrying varied across time. This was done by comparing the model where the parameters representing the association between violence exposure (T-1) and gun carrying (T) were constrained to be equal across the several time-points to a model where those parameters were allowed to vary. Constrained and unconstrained models were compared using a likelihood ratio chi square test (df=8). This comparison was done separately for gun and non-gun violence exposure. Supplemental analyses also tested whether the strength of the association between gun violence/non-gun violence exposure and gun carrying varied as a function of participants' age. This was accomplished by adding product terms for age at study initiation by gun and non-gun violence exposure to the fully adjusted model.

Results

Descriptive Statistics

Table 1 provides information on the prevalence of gun carrying, gun violence exposure, and non-gun violence exposure across the 10 assessments based on the observed (non-imputed) data. A total of 524 participants reported carrying a gun, 686 reported being exposed to gun violence, and 1037 participants reported being exposed to non-gun violence at least once during the study period.

Does exposure to gun and/or non-gun violence predict changes in gun carrying behavior?

Young men were significantly more likely to carry a gun in the time-point following exposure to gun violence compared to other time-points, controlling for all time-varying covariates (p<.001; see Table 2). Specifically, a young man's odds of gun carrying were increased by approximately 43% in recall periods after he was exposed to gun violence (Table 2). In contrast, exposure to non-gun violence was not significantly associated with gun carrying in the following time-point (see Table 2).

Does the association between violence exposure and changes in gun carrying vary from adolescence to young adulthood?

A series of follow-up analyses were conducted to examine whether the association between gun violence exposure and gun carrying varied from adolescence into the mid-20's. First, the final model was re-specified to allow the association between gun violence exposure and gun carrying to be freely estimated for each lagged path (T1 exposure → T2 carrying; T2 exposure → T3 carrying, etc.) rather than being constrained to be equal across time. The unconstrained model did not produce a significant improvement in model fit to the data

relative to the constrained model ($\Delta\chi^2$=9.62; *df*=8; *p*=.293). Similarly, the interaction between age at baseline and gun violence exposure was not significantly associated with gun carrying when added as a predictor in the final model (*z*=1.19, *p*=.235). Together, these findings indicate that the effects of gun violence exposure on subsequent gun carrying did not significantly change across the repeated assessments from adolescence to young adulthood.

Similarly, there was no substantive evidence that the association between *non*-gun violence exposure and gun carrying varied across time. However, an unconstrained model that allowed the lagged association from non-gun violence exposure to gun carrying to be freely estimated provided a significantly better fit to the data than the constrained model ($\Delta\chi^2$=20.08; *df*=8; *p*=.010). However, the only statistically significant lagged path in the unconstrained model indicated that exposure to non-gun violence at Time 7 was associated with a lower probability of gun carrying at Time 8 (*z*=−2.44, *p*=.015). The other 8 lagged paths were non-significant (*p*-values from .117 to .939). Moreover, the interaction between age at baseline and non-gun violence exposure was not significantly associated with gun carrying when added as a predictor in the final model (*z*=1.16, *p*=.246). Together, these findings indicated that exposure to non-gun violence is not significantly associated with an increased risk for future gun carrying at any time during adolescence and young adulthood.

We also compared the constrained model to models that allowed the effects of gun and non-gun violence to be estimated freely for the different recall period lengths (6 month vs 12 month), but the likelihood ratio chi square tests were not significant, suggesting that constrained model was a better fit to the data in each of these comparisons (gun violence: $\Delta\chi^2$=2.88; *df*=2; *p*=.237; non gun violence: $\Delta\chi^2$=3.30; *df*=2; *p*=.192).

Discussion

This study found that when young men with a history of criminal offending witness and/or are the victim of gun violence they are more likely to engage in future gun carrying. Specifically, an adolescent's odds of carrying a gun rose by over 40% in the recall period after he was exposed to gun violence. This association could not be accounted for by time stable factors that lead adolescents to become exposed to gun violence and carry guns, or time-varying changes in delinquent peers and exposure to non-gun violence. Furthermore, findings indicated that exposure to gun violence was associated with an increased risk for gun carrying across adolescence and into young adulthood.

There was no evidence that exposure to non-gun violence conferred the same risk for future gun carrying as exposure to gun violence among male juvenile offenders. This is an important finding, given that no prior study has examined the independent effects of exposure to gun violence and non-gun violence on subsequent carrying (11, 13–15, 17, 41). Exposure to gun violence may lead adolescents to engage in gun carrying because they begin to increasingly view it as a normative part of day-to-day life in their community. Similarly, adolescents exposed to gun violence may believe that carrying a weapon of similar force—a firearm—is the only effective way to protect themselves from future victimization or to proportionally retaliate against future attacks. Although it was outside the

scope of the present study, future research should investigate the precise reasons for gun carrying, as only some individuals who are exposed to gun violence run the risk of subsequently carrying guns. Future research should also examine the other possible negative psychosocial, behavioral, and mental health outcomes that could result from exposure to non-gun violence and gun-violence, as we only examined how these experiences influenced young men's risk of future gun carrying.

In addition to the primary finding that exposure to gun violence raises the risk of future gun carrying among male juvenile offenders, the sheer prevalence of gun carrying and violence exposure warrants particular attention. Among the male juvenile offenders in the current study, 45% had carried a gun, almost 60% were exposed to gun violence, and almost 90% were exposed to serious non-gun violence at least once during the study period. These figures underscore the salience of the high-risk lifestyle to which juvenile offenders are exposed.

The study is not without limitations. First, the measure of exposure to gun violence used in the present study focused on particularly severe acts—getting shot/shot at or witnessing someone else experience these events. Future studies should investigate whether exposure to less severe forms of gun violence, such as being threatened or intimidated with a gun, are also related to future gun carrying. Second, analyses focused on a sample of male juvenile offenders who demonstrated considerable fluctuations in violence exposure and gun carrying over time. Although this provided the unique opportunity to investigate linkages between changes in victimization and gun carrying within-individuals, the results may not generalize to females or community-based samples. It is also important to note that not all juveniles exposed to gun violence will carry guns in the future. As such, future research should examine the factors that identify which youth exposed to gun violence are most at risk of future gun carrying (i.e., moderators). Moreover, although the overall prevalence of gun carrying might change over time, there is no reason to suspect that the drivers of gun carrying (e.g., exposure to gun violence) would also change over time. Additionally, we were not able to separate personally experienced gun violence (e.g., personally being shot) from witnessed gun violence (e.g., observing someone else getting shot) because almost everyone who personally experienced gun violence also reported witnessing it. Furthermore, the present study did not ask participants to report the perpetrator for each act of violence, which could affect the nature of the impact of gun or non-gun violence. Future studies should include these data to determine whether the relationship of the perpetrators (e.g., family member, stranger) is more influential for future gun carrying than the act of violence itself.

Furthermore, the measures of peer gun use and peer non-gun delinquency were reported by the study participant, which could have resulted in errors due to projection or overestimation. It was interesting that peer non-gun delinquency had a stronger impact on gun carrying than peer gun carrying alone, which suggests that having peers who engage in a variety of illegal behaviors is a critical risk factor for gun carrying. Finally, this study only included a subset of the potential time-varying covariates that could affect the associations presented here. Future studies should continue to explore additional time-varying covariates that might account for the association between exposure to gun violence and gun carrying.

We explored the utility of time varying indicators of probation status, number of probation officer contacts, gainful activity, drug dealing, gang membership, neighborhood disadvantage, and alcohol use, but none were significantly associated with gun carrying after controlling for exposure to violence and peer delinquency thus none were retained as additional covariates. Future studies should also examine the extent to which the opposite direction—youths' gun carrying predicting subsequent violence exposure—accounts for the findings presented here.

The study indicates that young men with a history of criminal offending are more likely to carry a gun after being exposed to gun-related violence in the community. This is consistent with other research that has found that emergency room patients who are treated for firearm-related injuries are at heightened risk of future violent behavior (including firearm carrying), in addition to future firearm related injuries and even firearm-related death (42). Taken together, the results suggest that a comprehensive approach to prevent adolescent and young adult gun carrying should include empirically-based strategies designed to reduce overall levels of gun violence in the communities to which young people are exposed, such as targeting policing strategies (43). In addition, trauma-informed interventions that target adolescents and young adults exposed to gun violence could be pivotal in preventing future gun-related morbidities and mortalities. Toward this end, hospitals and mental health care systems should screen and refer vulnerable patients to trauma-informed intervention programs (44)—because doing so could ultimately save lives.

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Table 1

Sample Descriptive Statistics for Analysis Variables

	N	Age M (SD)	Gun Carrying % (n)	Gun Violence % (n)	Non-Gun Violence % (n)
6 Month Assessments					
Time 1	1094	17.08 (1.12)	15.23 (134)	16.90 (184)	53.03 (578)
Time 2	1087	17.55 (1.12)	14.25 (128)	17.77 (193)	46.87 (509)
Time 3	1058	18.04 (1.12)	15.31 (139)	16.08 (170)	44.28 (468)
Time 4	1061	18.53 (1.11)	13.82 (127)	12.18 (129)	37.68 (399)
Time 5	1061	19.01 (1.12)	11.72 (107)	12.83 (136)	37.74 (400)
Time 6	1056	19.51 (1.12)	12.25 (110)	12.41 (131)	34.28 (362)
12 Month Assessments					
Time 7	1042	20.53 (1.12)	17.18 (163)	18.54 (193)	42.36 (441)
Time 8	1031	21.52 (1.12)	15.96 (151)	17.51 (180)	38.62 (397)
Time 9	1004	22.54 (1.12)	12.47 (116)	13.66 (137)	40.08 (402)
Time 10	962	23.54 (1.12)	9.67 (83)	10.64 (102)	39.42 (378)

Note: Descriptive statistics based on observed data (non-imputed). Assessments conducted every 6 months from Time 1–6 and then every 12 months from Time 7–10.

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Table 2

Within-Individual Associations Between Gun and Non-Gun Violence and Gun Carrying Among Male Juvenile Offenders (N=1170)

	Odds Ratio	95% CI	*p*	Estimated Missing Rate
Time-varying predictors				
Gun violence exposure	1.43	[1.17, 1.75]	0.001	0.19
Non-gun violence exposure	1.01	[0.82, 1.23]	0.959	0.23
Institutional placement	2.65	[2.10, 3.33]	<.001	0.19
Street months	1.21	[1.17, 1.25]	<.001	0.25
Peer non-gun delinquency	1.20	[1.05, 1.37]	0.008	0.21
Peer gun carrying	1.03	[0.94, 1.12]	0.577	0.17

Note: All models estimated with binary fixed effects logistic regressions in a structural equation framework with maximum likelihood estimation. Rate of missingness differs from the proportion of missing data per variable because it is estimated based on the missing data mechanism, model specification, and associations among analysis variables (45). It is used to determine the extent to which each parameter is affected by missing data (45). A value of .19, for example, indicates that the loss of efficiency due to incomplete data for that particular parameter is 19% (45).